US009939010B2

(12) **United States Patent**
Yamamoto et al.

(10) **Patent No.: US 9,939,010 B2**
(45) **Date of Patent: Apr. 10, 2018**

(54) **THRUST ROLLER BEARING CAGE AND METHOD FOR MANUFACTURING THE SAME**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/523,408**

(22) PCT Filed: **Nov. 6, 2015**

(86) PCT No.: **PCT/JP2015/081273**
§ 371 (c)(1),
(2) Date: **May 1, 2017**

(87) PCT Pub. No.: **WO2016/080208**
PCT Pub. Date: **May 26, 2016**

(65) **Prior Publication Data**

US 2017/0307007 A1 Oct. 26, 2017

(30) **Foreign Application Priority Data**

Nov. 18, 2014	(JP)	2014-233493
Dec. 15, 2014	(JP)	2014-253274
Jan. 9, 2015	(JP)	2015-003487
Jan. 9, 2015	(JP)	2015-003505
Jan. 9, 2015	(JP)	2015-003508
Jan. 9, 2015	(JP)	2015-003512

(51) **Int. Cl.**
F16C 33/46 (2006.01)
F16C 19/46 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F16C 19/463*** (2013.01); ***B21D 53/12*** (2013.01); ***F16C 19/305*** (2013.01); ***F16C 33/546*** (2013.01); *F16C 2326/01* (2013.01)

(58) **Field of Classification Search**
CPC F16C 19/305; F16C 19/463; F16C 33/541; F16C 33/543; F16C 33/545; F16C 33/546
See application file for complete search history.

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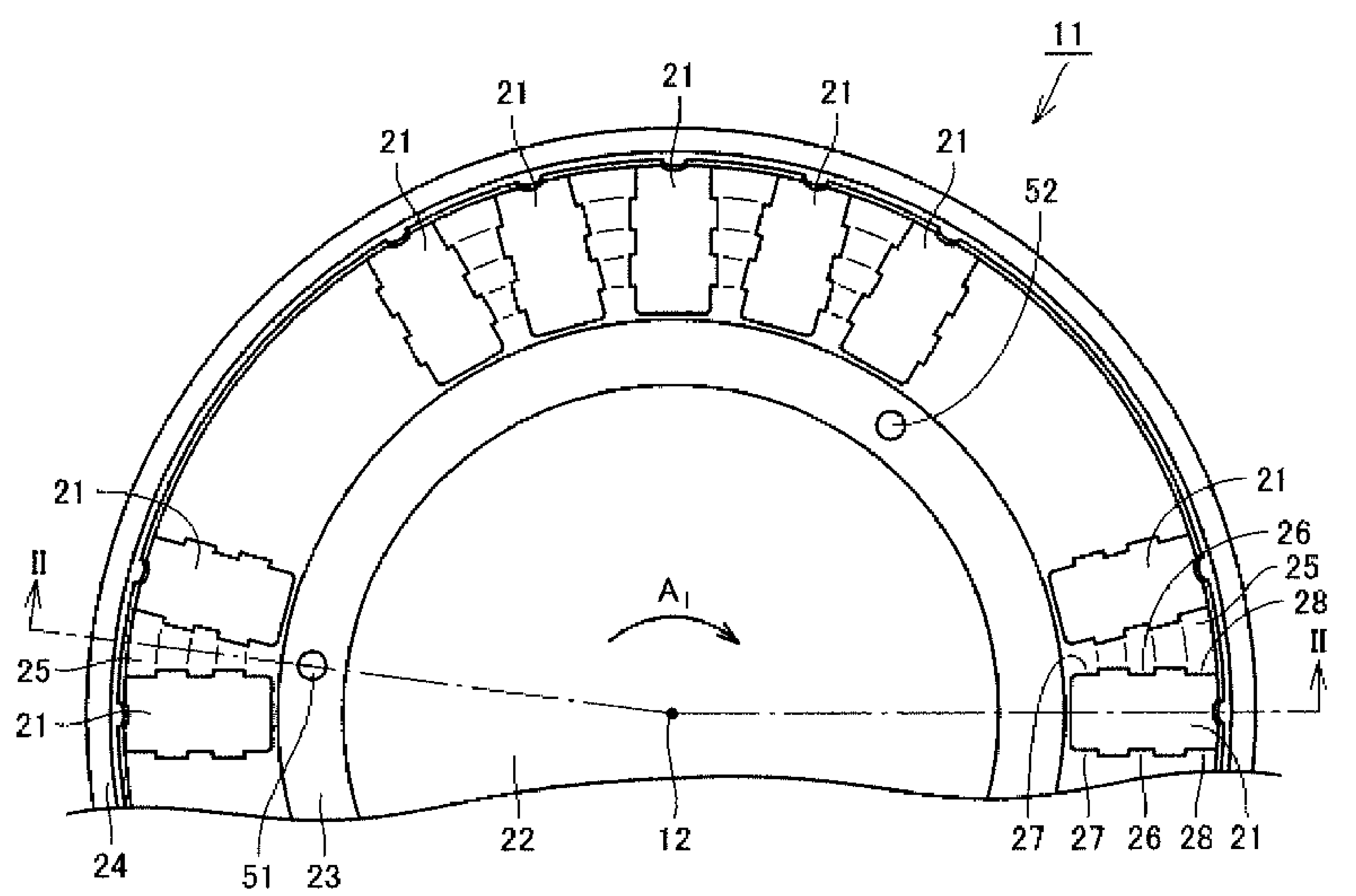
(74) *Attorney, Agent, or Firm* — Clark & Brody

(57) **ABSTRACT**

A thrust roller bearing cage (**11**) of the present invention is included in a thrust roller bearing (**20**) and includes a plurality of pockets (**21**) accommodating rollers (**13**). The thrust roller bearing cage (**11**) includes: a radially outer area bent portion (**41**) formed by bending the cage (**11**) inward in a radial direction along an annular groove formed at a position radially outside the pockets (**21**); and projecting portions (**44**) that are formed in a tip end of the radially outer area bent portion (**41**) at positions aligned with the pockets (**21**) and project inward in the radial direction beyond radially outer edges of the pockets (**21**) so as to contact end faces (**16**) of the rollers (**13**) accommodated in the pockets (**21**). A trace (**29**) of the groove is left at a position along which the cage is bent.

4 Claims, 8 Drawing Sheets



(51) **Int. Cl.**

B21D 53/12	(2006.01)
F16C 19/30	(2006.01)
F16C 33/54	(2006.01)

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FIG.1

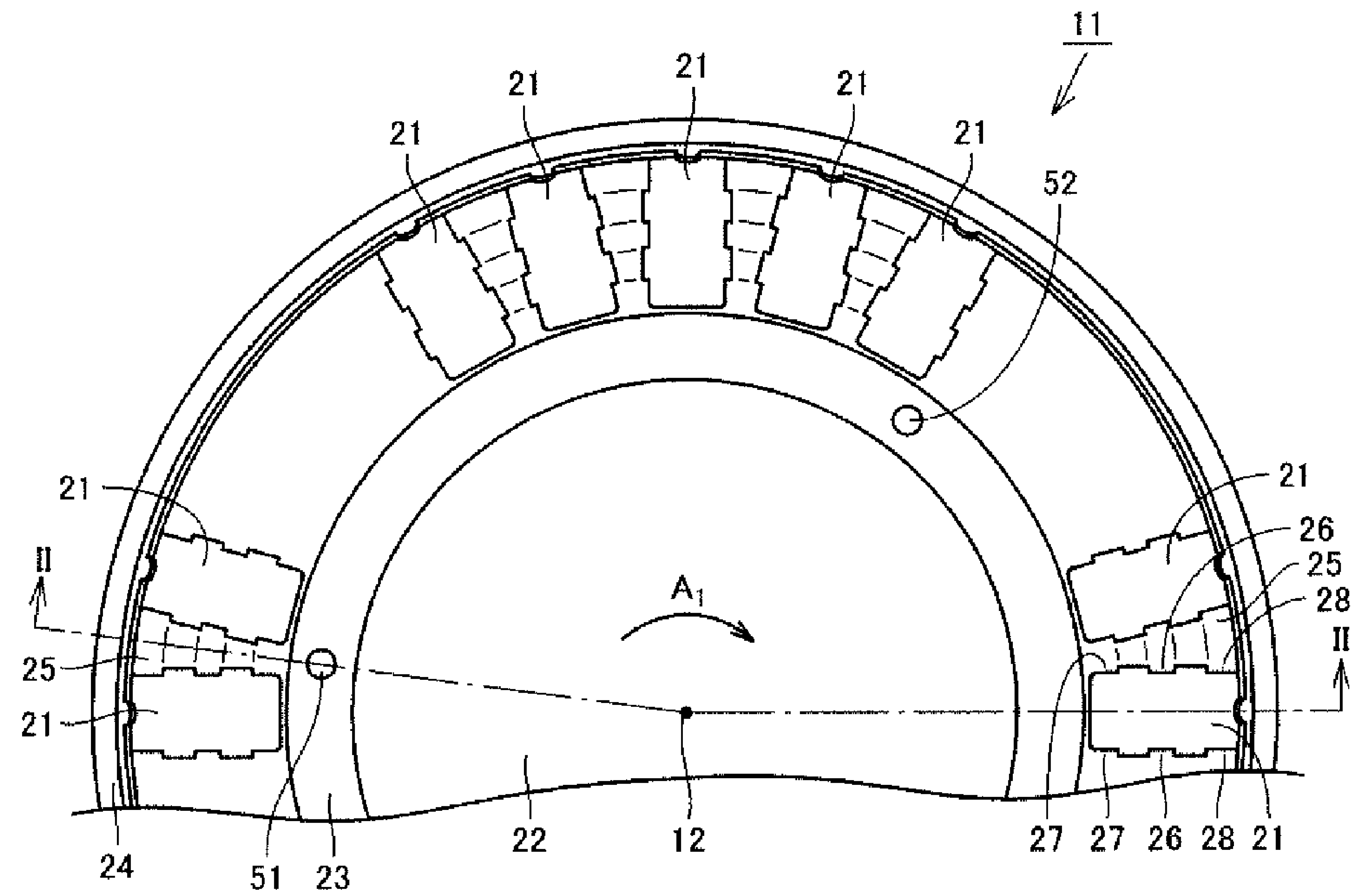
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FIG.2

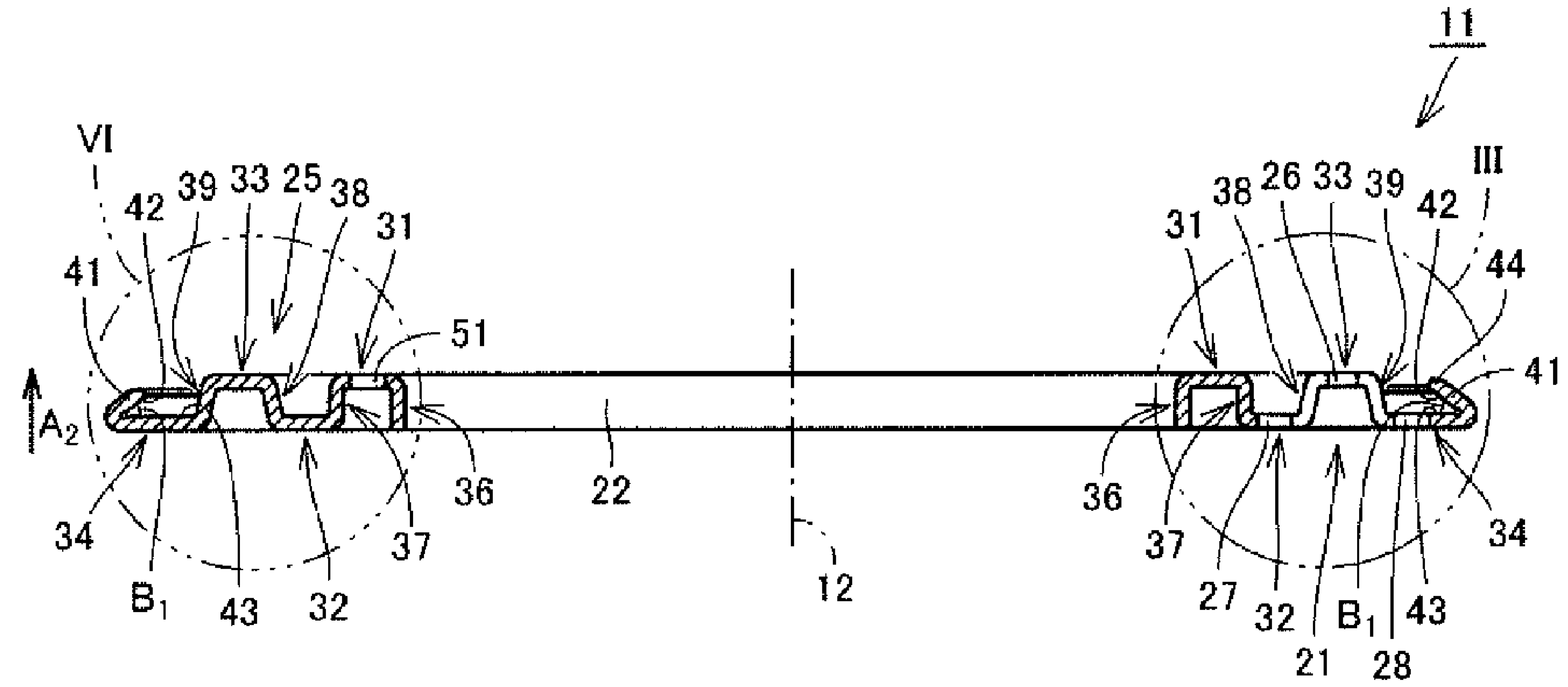
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FIG.3

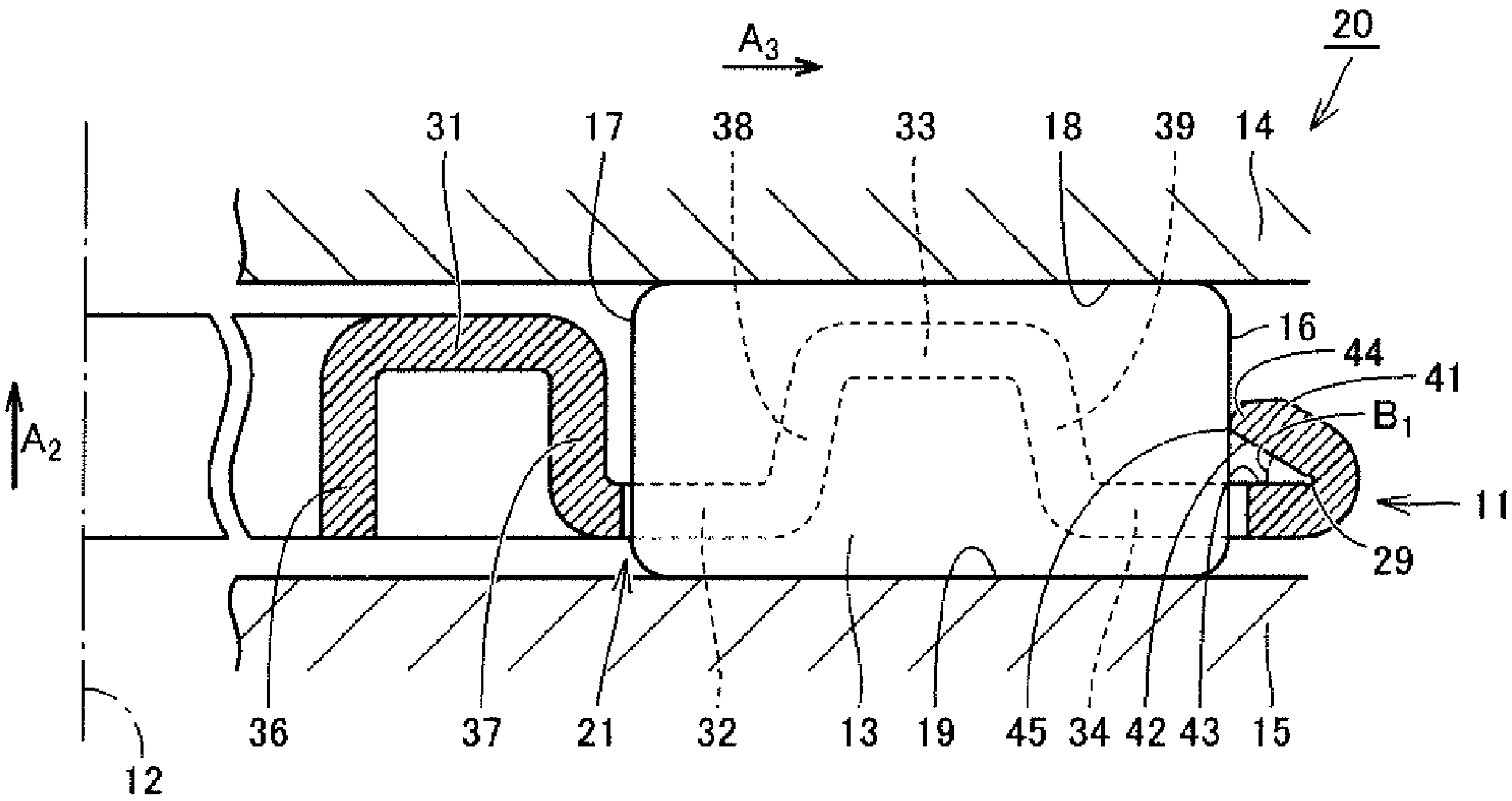

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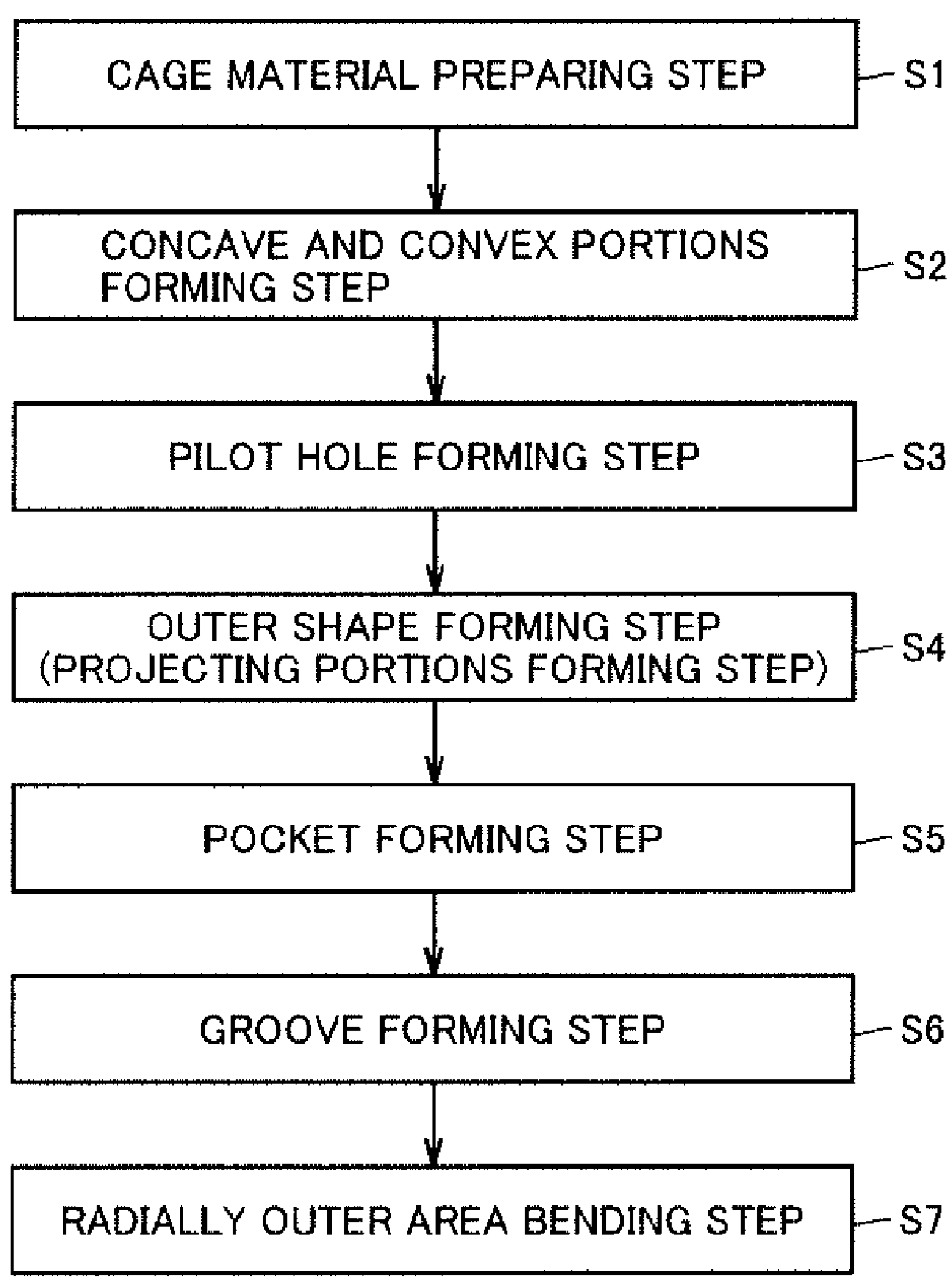
FIG.4



CAGE MATERIAL PREPARING STEP
S1
CONCAVE AND CONVEX PORTIONS FORMING STEP
S2
PILOT HOLE FORMING STEP
S3
OUTER SHAPE FORMING STEP (PROJECTING PORTIONS FORMING STEP)
S4
POCKET FORMING STEP
S5
GROOVE FORMING STEP
S6
RADIALLY OUTER AREA BENDING STEP
S7

FIG.5

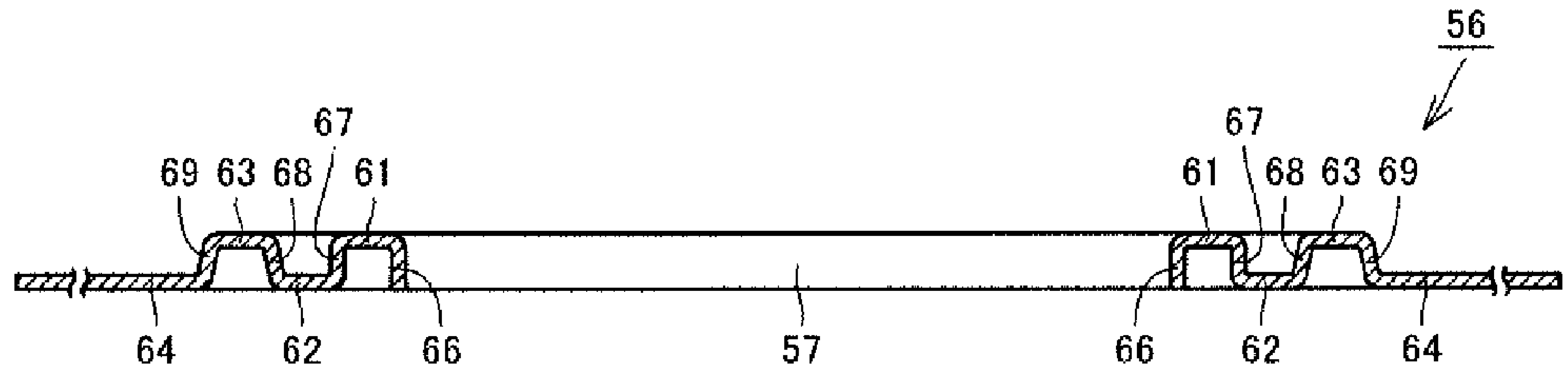


FIG.6

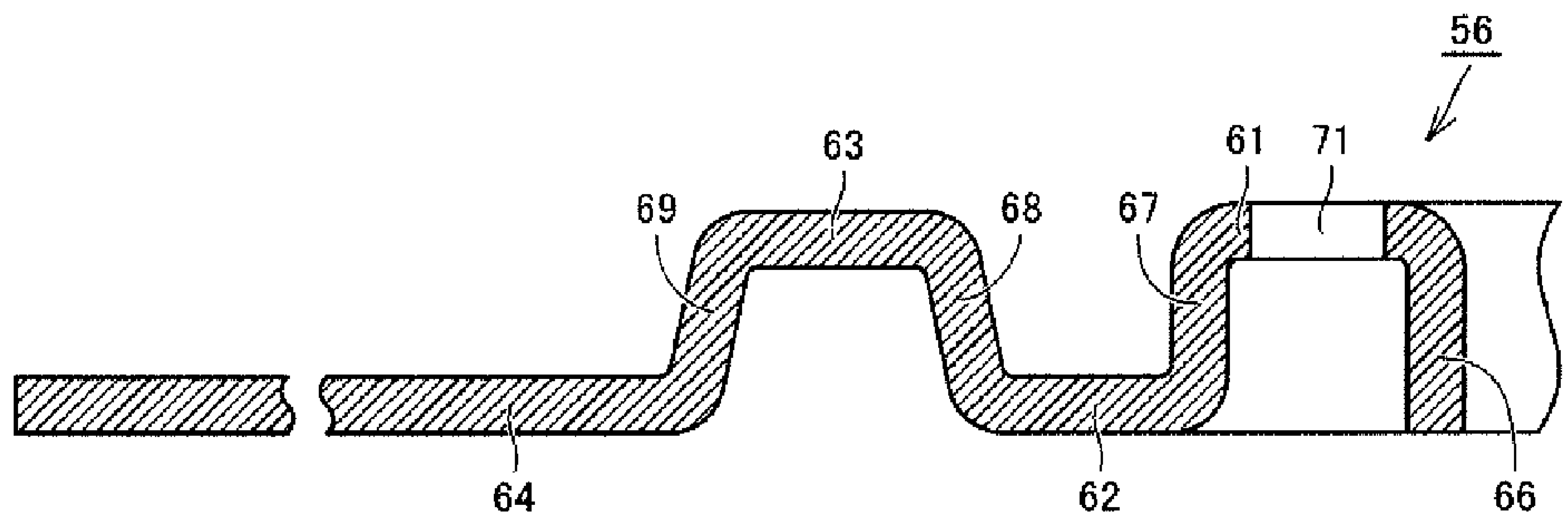


FIG.7

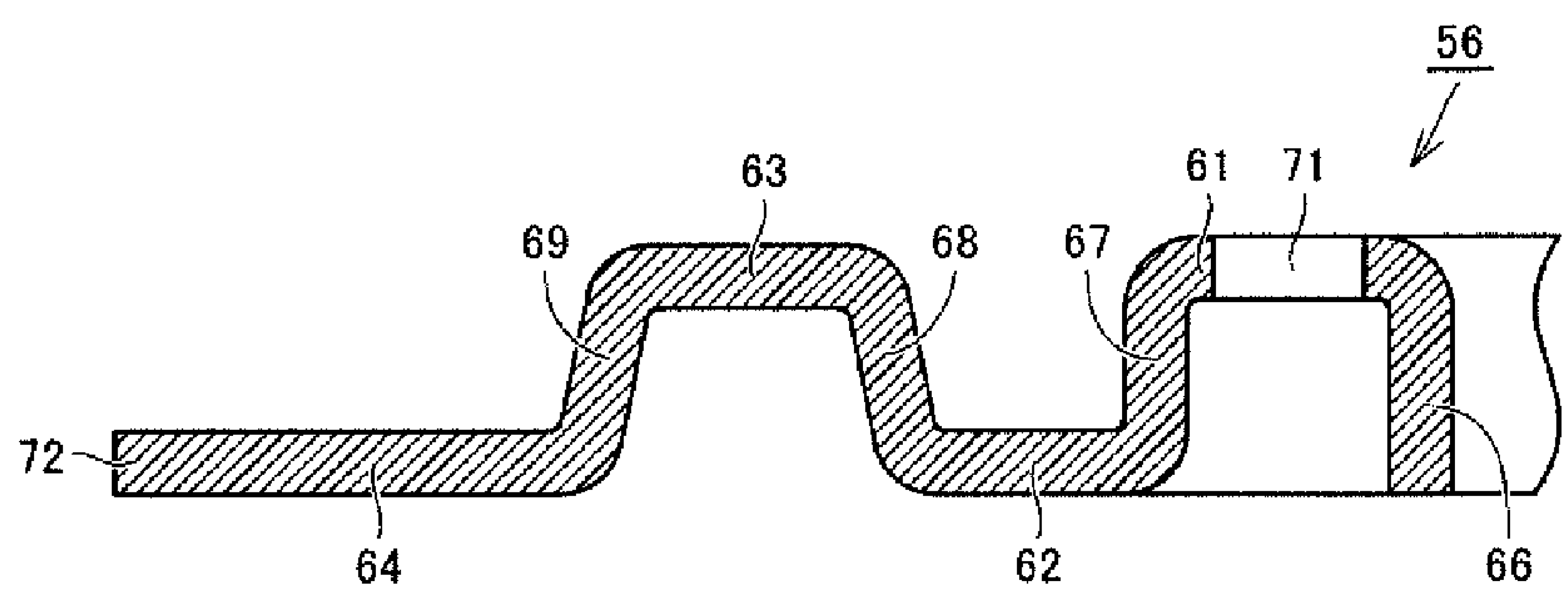


FIG.8

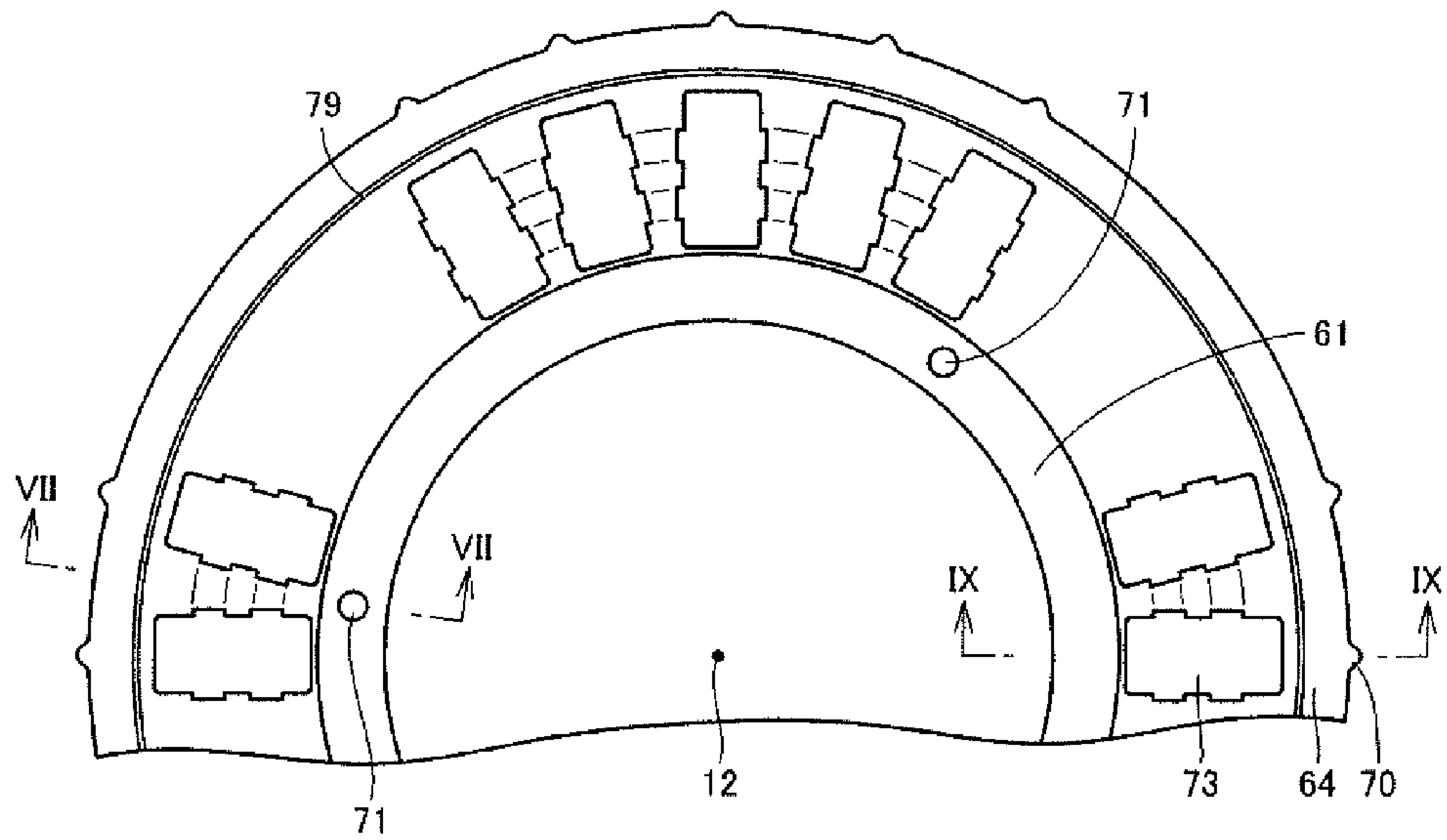


FIG.9

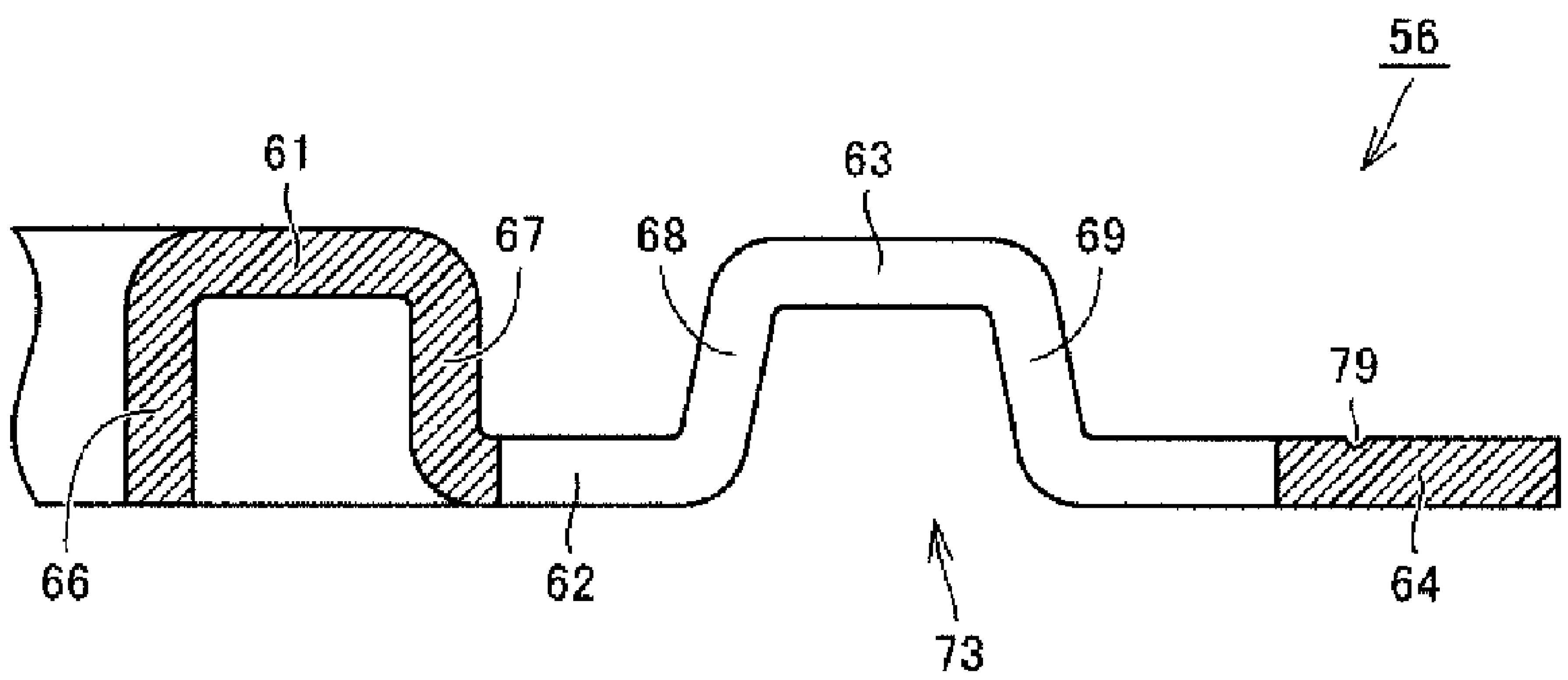


FIG.10

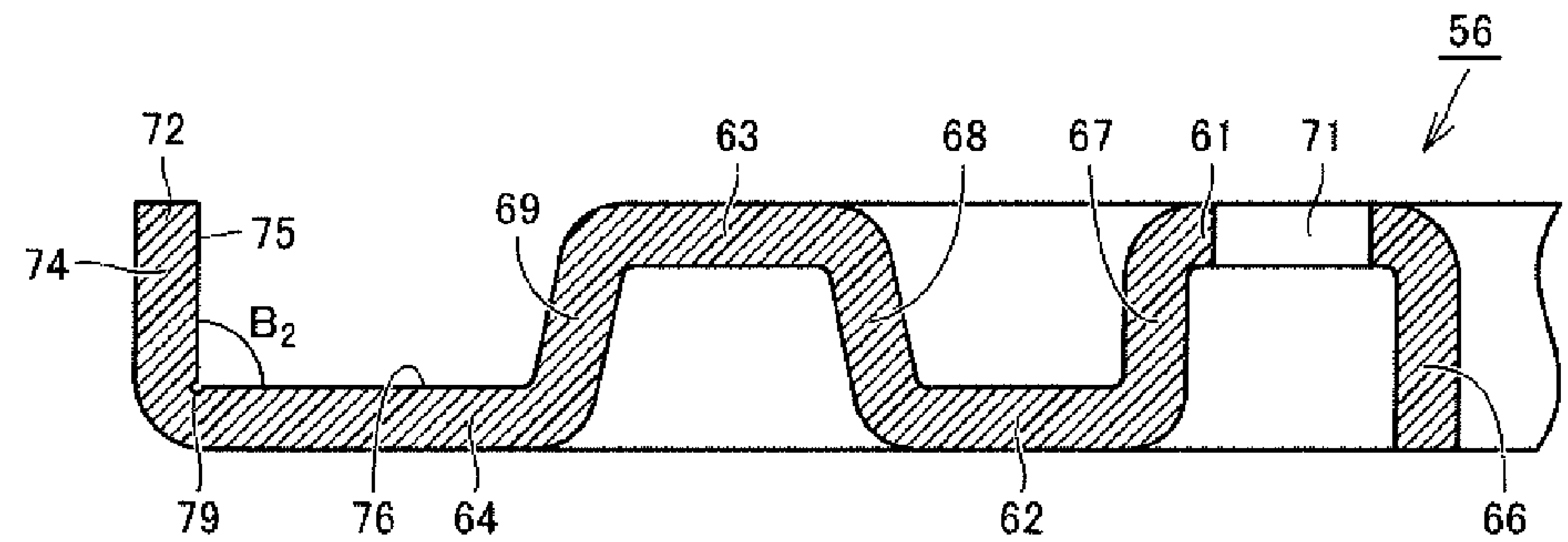


FIG.11

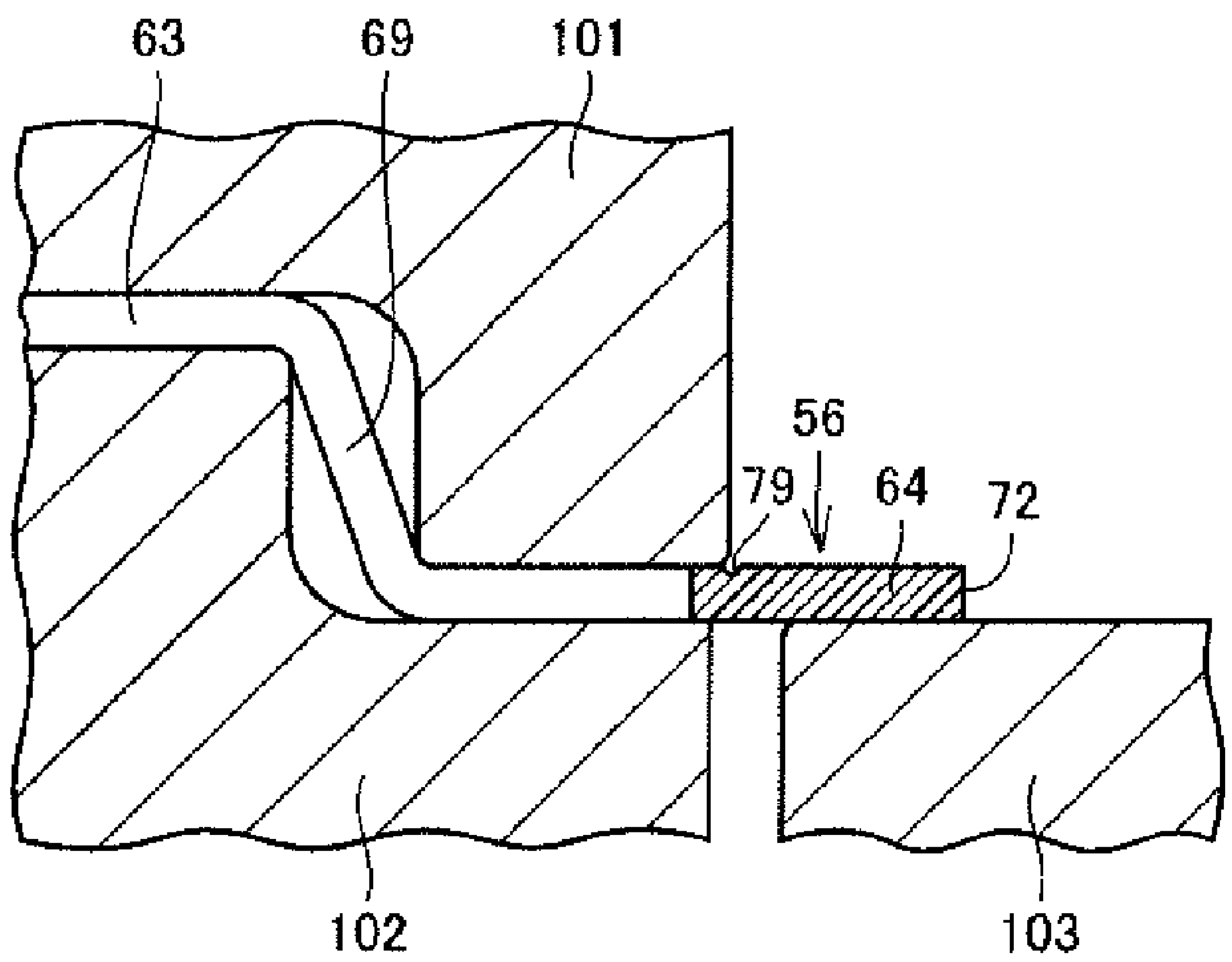


FIG.12

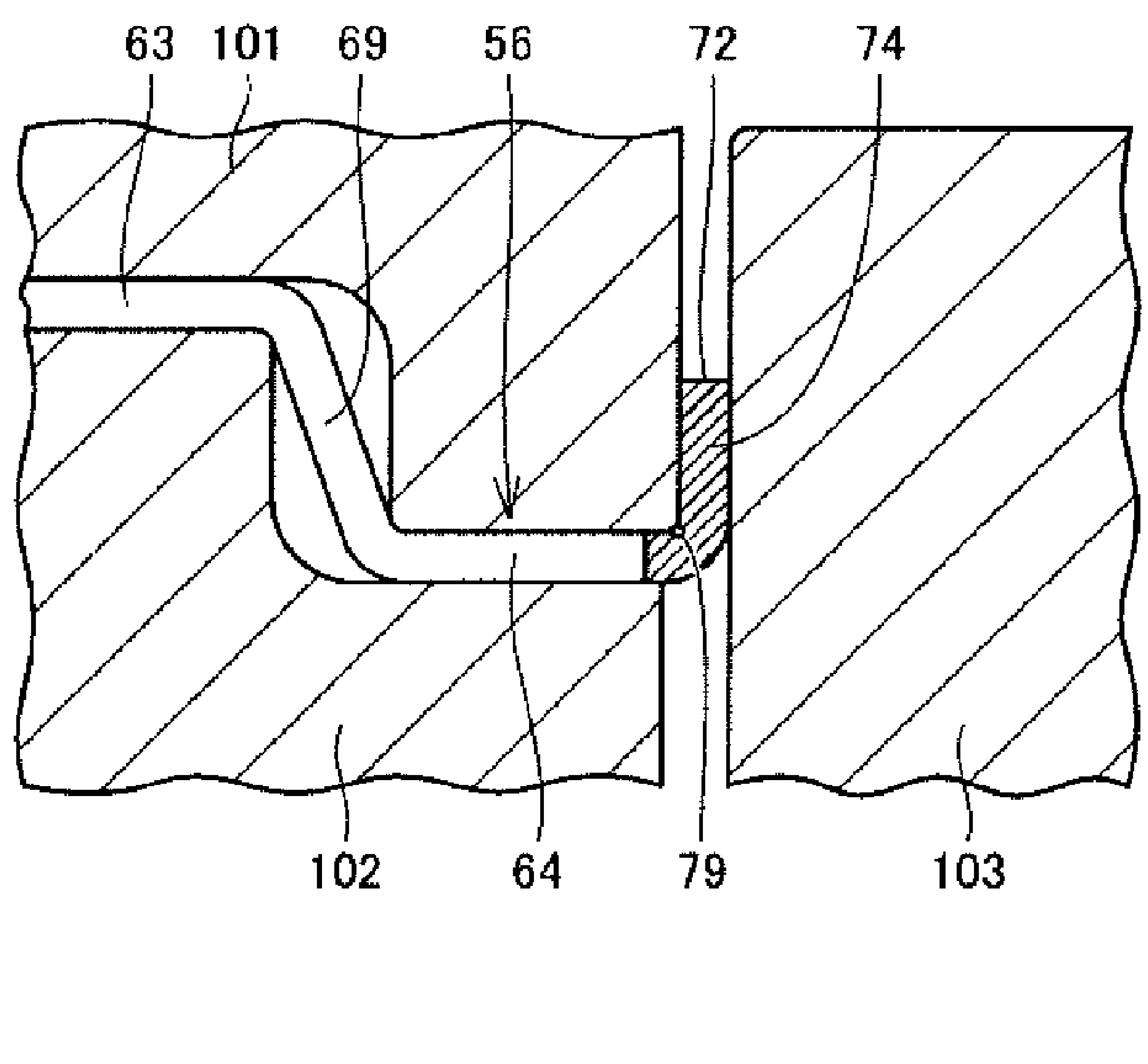


FIG.13

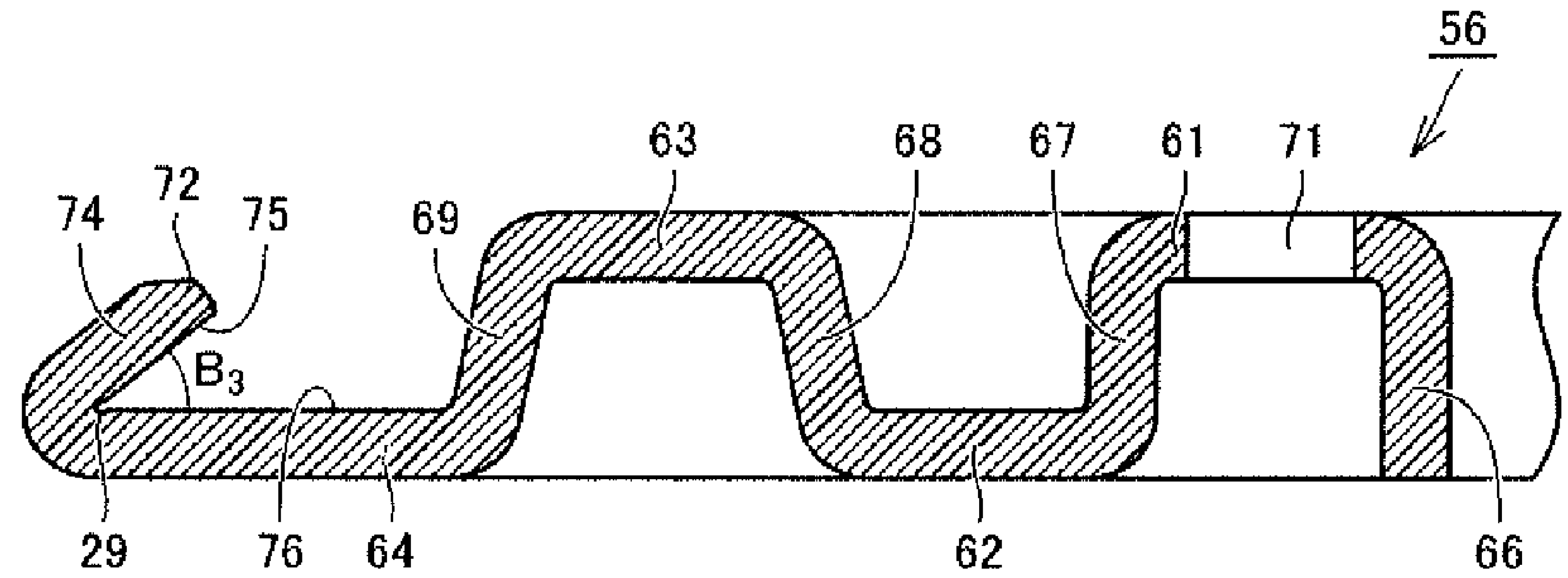


FIG.14

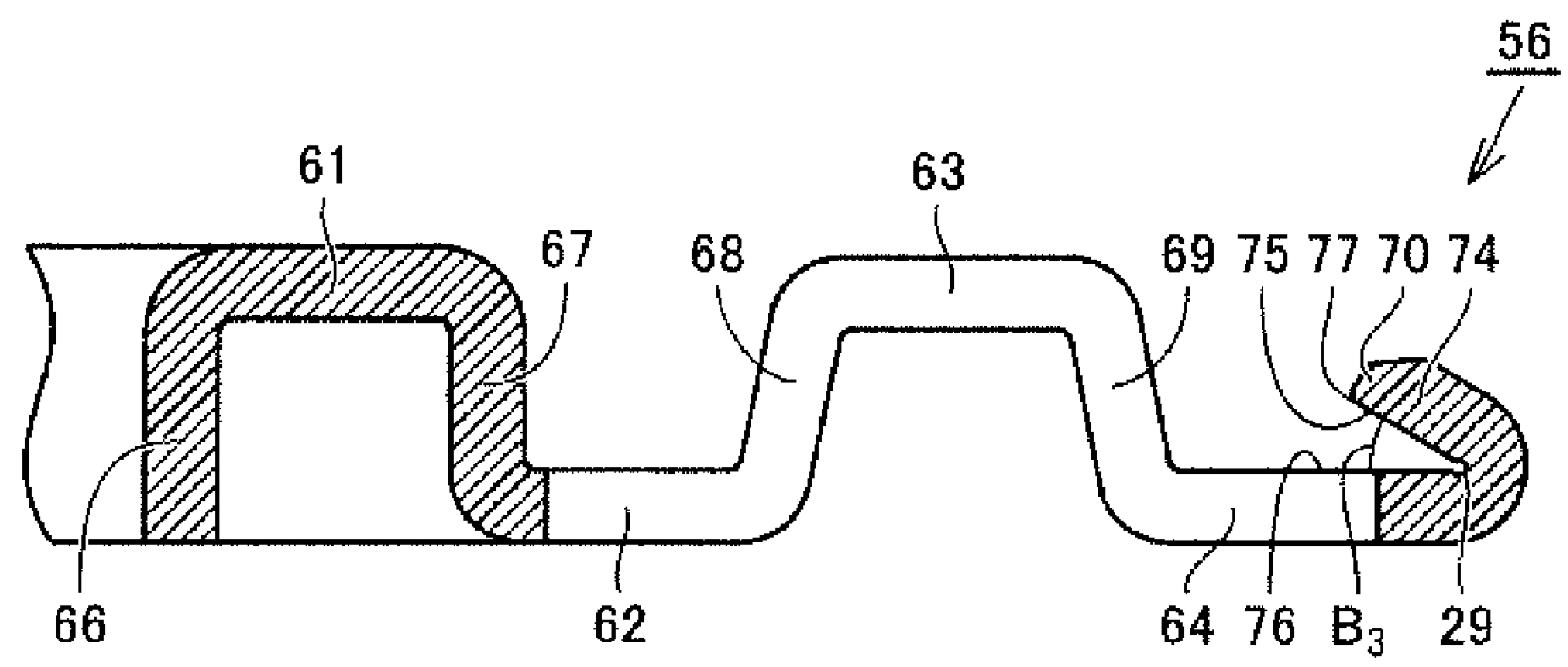


FIG.15

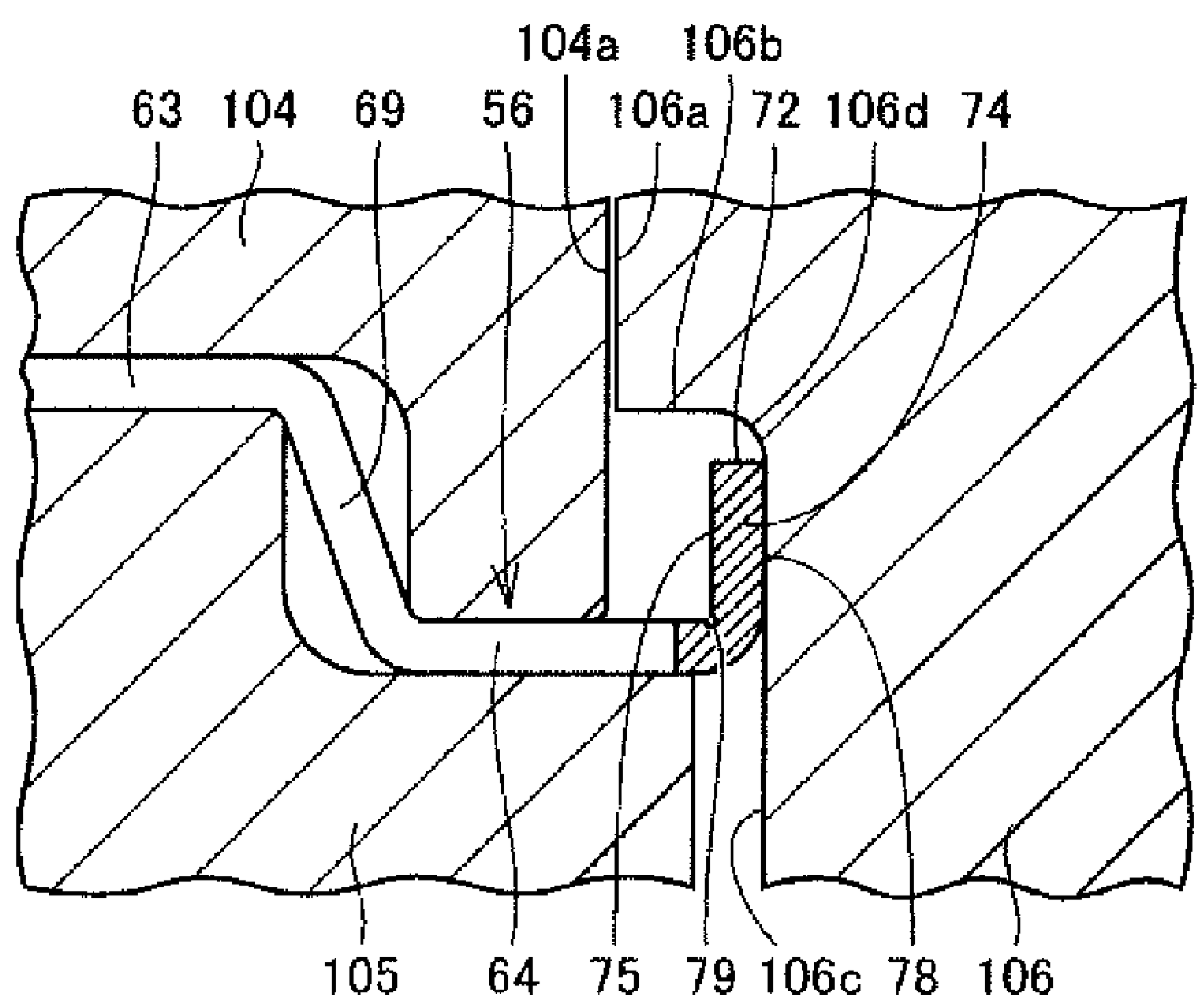


FIG.16

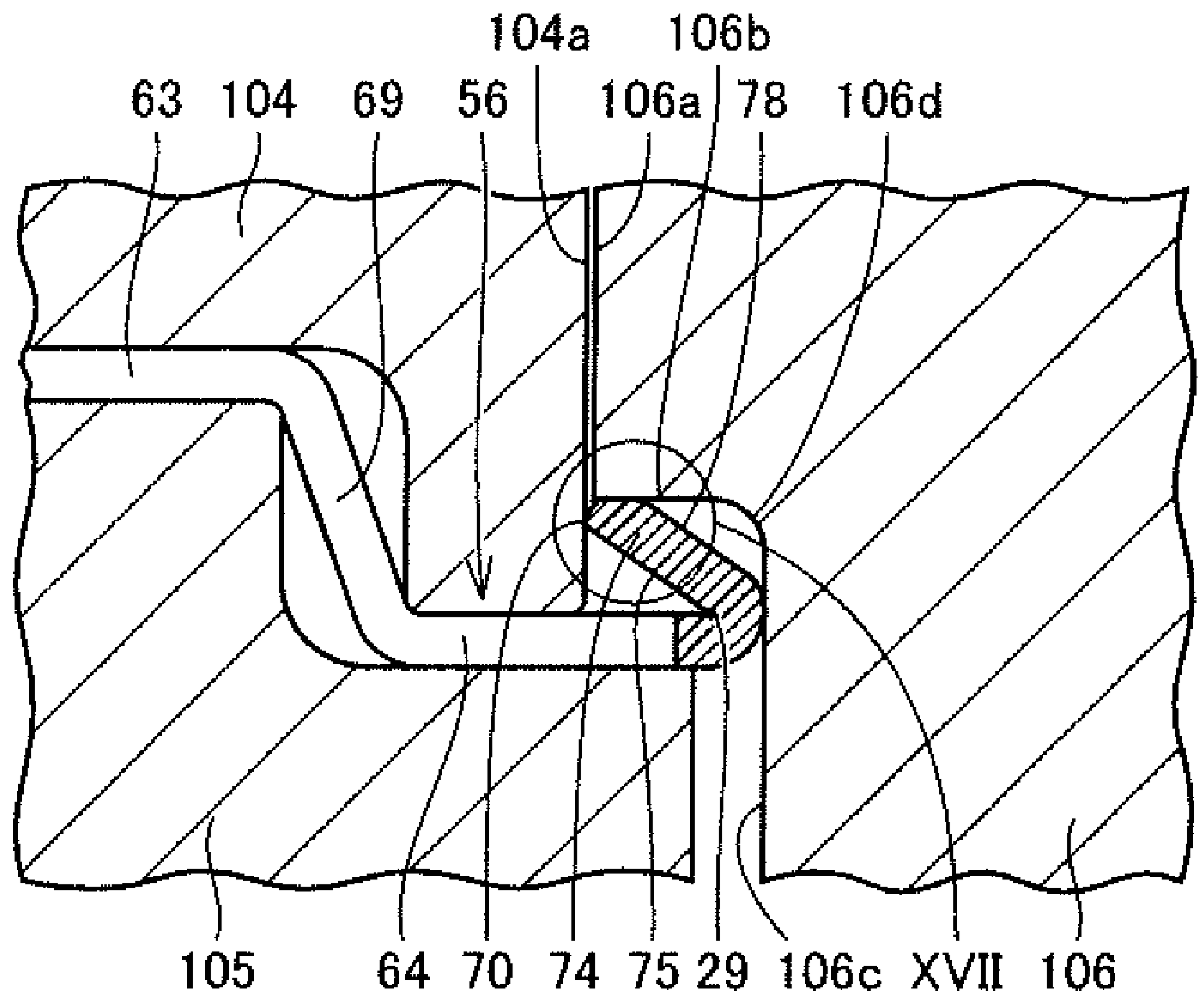

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FIG.17

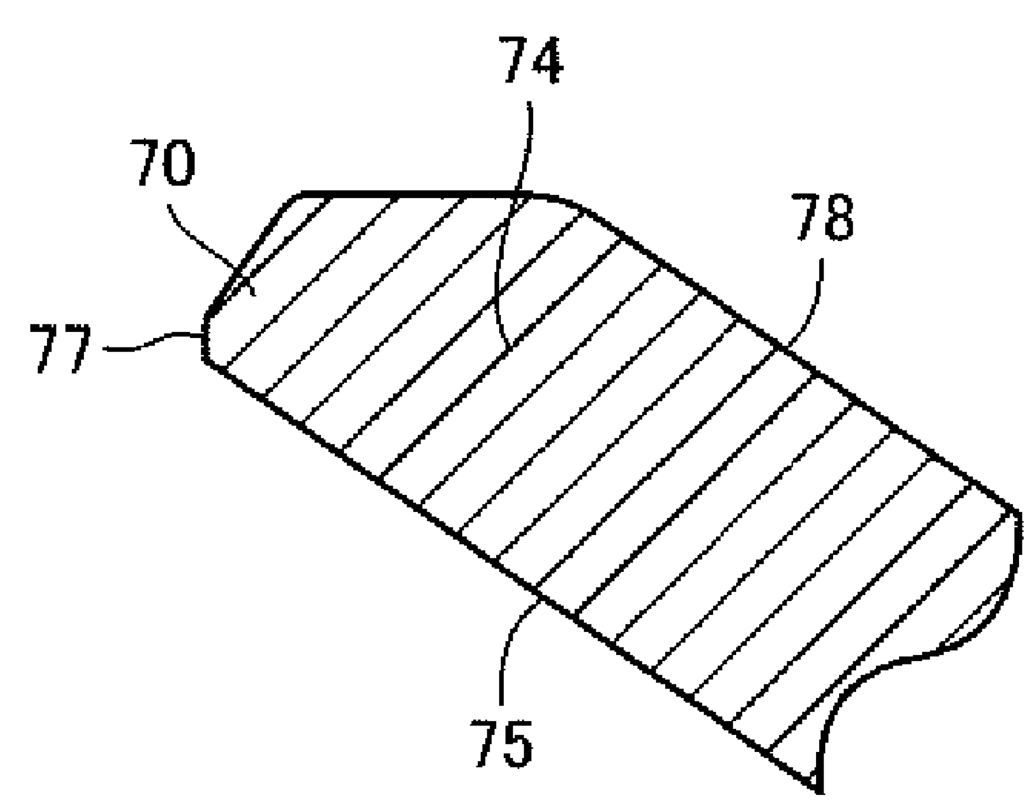
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FIG.18

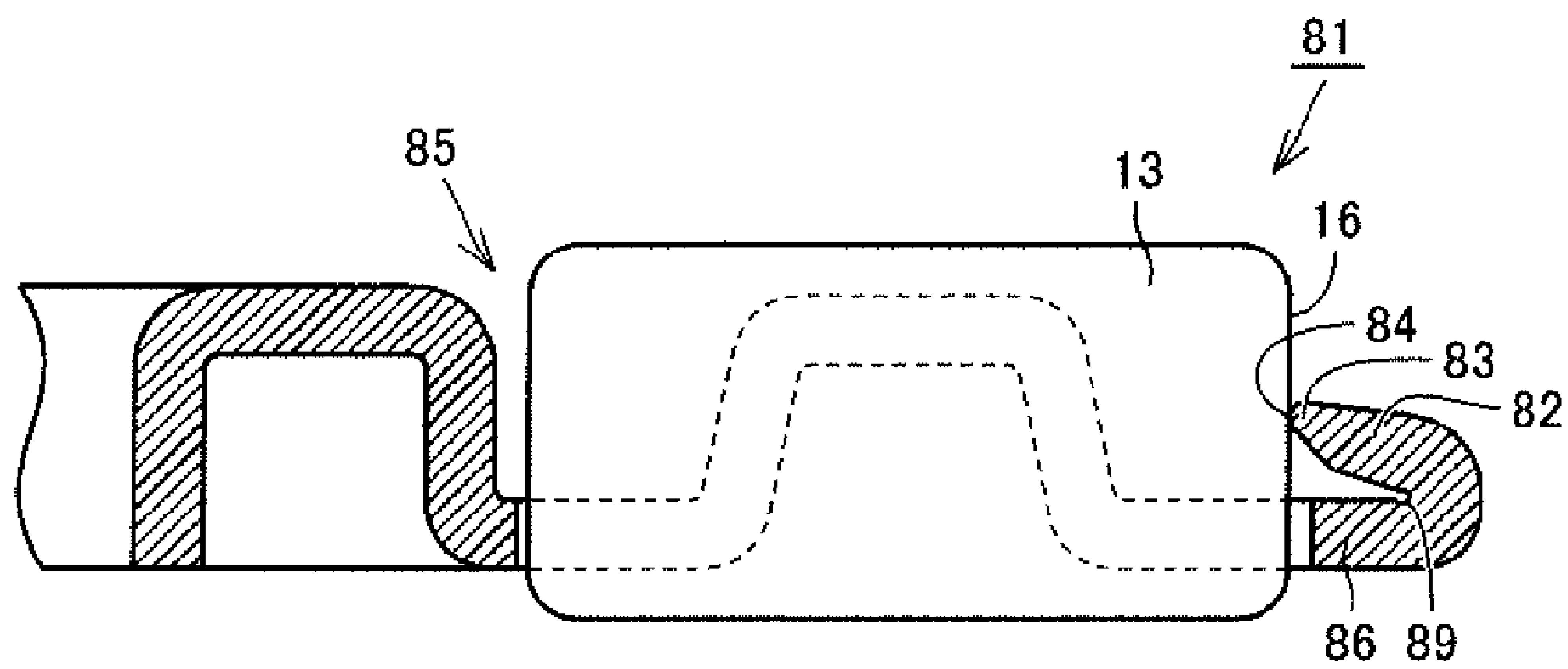
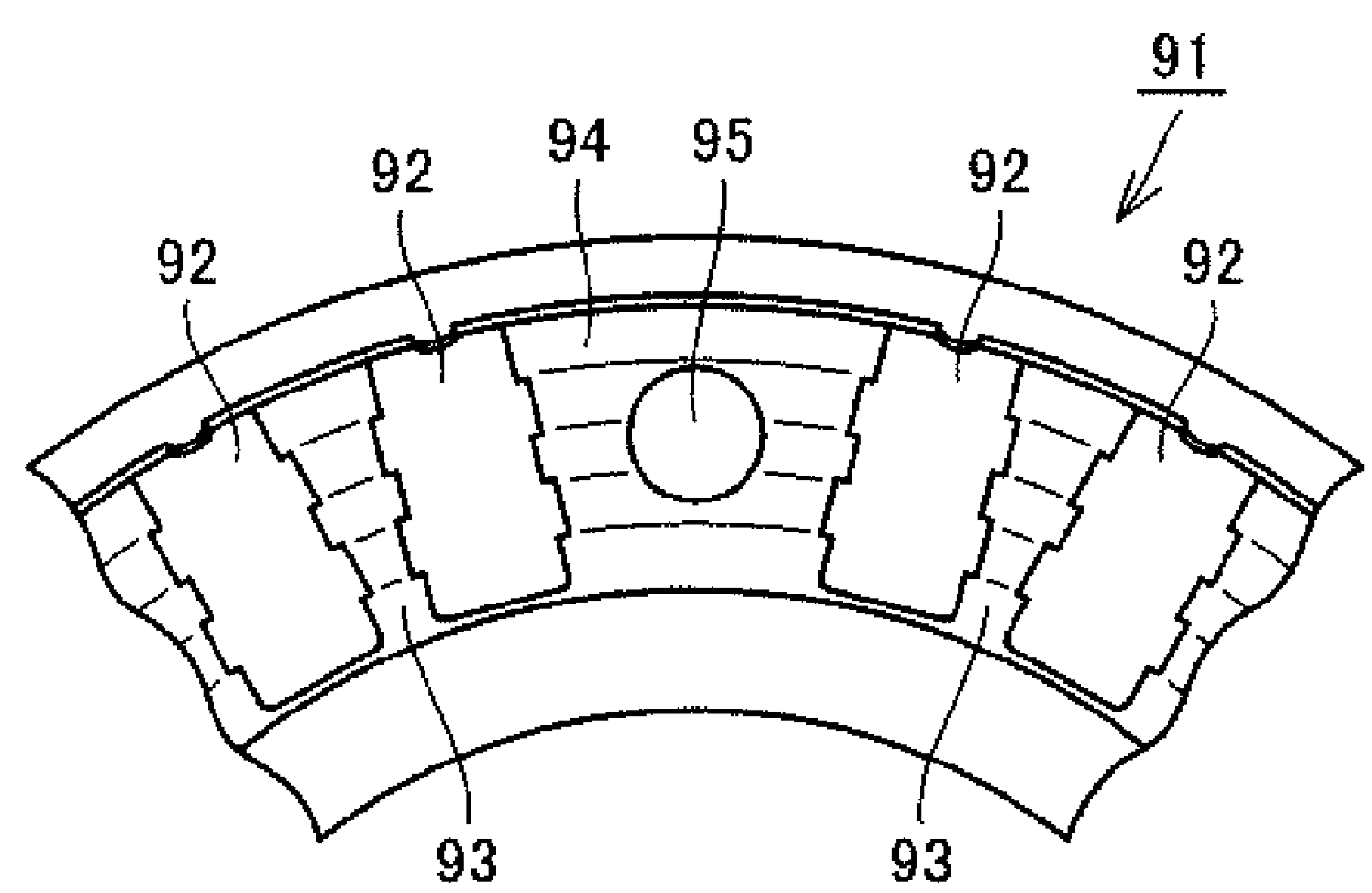


FIG.19



THRUST ROLLER BEARING CAGE AND METHOD FOR MANUFACTURING THE SAME

TECHNICAL FIELD

The present invention relates to thrust roller bearing cages (hereinafter sometimes simply referred to as the "cages") and methods for manufacturing the same, and more particularly relates to a thrust roller bearing cage that is manufactured by using a press and a method for manufacturing the same.

BACKGROUND ART

For example, thrust roller bearings that support thrust loads are sometimes placed at such locations in automatic transmissions for automobiles, car air conditioner compressors, etc. that are subjected to thrust loads. For improved fuel efficiency and power saving, it is desired to reduce running torque of such thrust roller bearings. A thrust roller bearing includes bearing rings arranged in the direction of the rotation axis of the thrust roller bearing, a plurality of needle rollers that roll on raceway surfaces of the bearing rings, and a cage that retains the plurality of needle rollers. Some cages are manufactured by bending a steel sheet and then punching out pockets that accommodate the rollers.

A technique relating to the cages included in such thrust roller bearings is disclosed in, e.g., Japanese Unexamined Patent Publication No. H10-220482 (Patent Literature 1). The thrust roller bearing cage of Patent Literature 1 includes an annular body formed by cutting, punching, etc. and projecting portions formed in a radially outer part of the annular body. The projecting portions are formed such that those parts of the radially outer end face of the folded part of the annular body which are located at the positions of the pockets project inward in the radial direction, and the tip ends of the projecting portions face approximately the centers of the end faces of the rollers.

CITATION LIST

Patent Literatures

Patent Literature 1: Japanese Unexamined Patent Application Publication No. H10-220482

SUMMARY OF INVENTION

Technical Problem

In order to reduce running torque, it is desirable that the tip ends of the projecting portions contact approximately the centers of the radially outer ends faces of the rollers in Patent Literature 1. In Patent Literature 1, however, the tip ends of the projecting portions are sometimes displaced from their desired positions, and in such a case, the running torque is not sufficiently reduced.

It is an object of the present invention to provide a thrust roller bearing cage that reduces running torque and a method for manufacturing the same.

Solution to Problem

The inventors found out the reason why the tip ends of the projecting portions do not contact the centers of the radially outer ends faces of the rollers in Patent Literature 1. Since the folded part of the annular body, which is located outside the folding position in the radial direction, has a small length in the radial direction, namely since the height of the folded part is small, it is difficult to fold the annular body, and the folding position is displaced from its desired position. The inventors completed the present invention through their intensive research regarding means for improving accuracy of the folding position of the annular body and easily folding the annular body.

A thrust roller bearing cage according to the present invention is a thrust roller bearing cage included in a thrust roller bearing and including a plurality of pockets accommodating rollers. The thrust roller bearing cage includes: a radially outer area bent portion formed by bending the cage inward in a radial direction along an annular groove formed at a position radially outside the pockets; and projecting portions that are formed in a tip end of the radially outer area bent portion at positions aligned with the pockets and project inward in the radial direction beyond radially outer edges of the pockets so as to contact end faces of the rollers accommodated in the pockets. A trace of the groove is left at a position along which the cage is bent.

A method for manufacturing a thrust roller bearing cage according to the present invention is a method for manufacturing a thrust roller bearing cage included in a thrust roller bearing and including a plurality of pockets accommodating rollers. The method includes the steps of: preparing a cage material that will later become the cage; forming an outer shape of the cage material so that the outer shape has portions that will later become projecting portions projecting inward in a radial direction beyond radially outer edges of the pockets so as to contact end faces of the rollers accommodated in the pockets; forming the pockets in the cage material; forming an annular groove at a position radially outside the pockets in the cage material; and forming a radially outer area bent portion by bending an area of the cage material which is located radially outside the pockets inward in the radial direction along the annular groove.

According to the thrust roller bearing cage of the present invention and the method for manufacturing the same, the radially outer area bent portion is formed by bending the cage inward in the radial direction along the annular groove formed at the position radially outside the pockets. Since the annular groove serves as a bending position, displacement of the bending position can be prevented. Moreover, the annular groove facilitates bending even when the height of the bent portion is small. Since the annular groove improves positional accuracy of the radially outer area bent portion and facilitates bending, the projecting portions formed in the tip end of the radially outer area bent portion can contact approximately the centers of the radially outer end faces of the rollers, whereby running torque can be reduced.

In the thrust roller bearing cage according to the present invention, it is preferable that areas of the projecting portions which are to contact the end faces of the rollers be subjected to a press-flattening process.

It is preferable that the method for manufacturing the thrust roller bearing cage according to the present invention further includes the step of: press-flattening areas of the projecting portions which are to contact the end faces of the rollers.

Since the areas of the projecting portions which are to contact the end faces of the rollers are subjected to the press-flattening process, this can reduce the risk that discontinuity of a lubricant film will be caused during rotation of the bearing by the sliding motion of the end faces of the rollers on the areas of the projecting portions which contact the end faces of the rollers. This improves lubricating properties in the contact areas and reduces what is called aggression of the rollers against the projecting portions of the cage. Such a thrust roller bearing cage can thus further reduce the running torque of the bearing.

As used herein, the "press-flattening process" means a process in which, in the step of forming the radially outer area bent portion, the projecting portions are pressed outward in the radial direction by using a radially outer surface of a die that serves as a stopper to control the amount of collapse, in order to smooth the rough surfaces of the projecting portions before and after the process. Specifically, the press-flattening process can smooth a press-sheared surface or a fracture surface, which is formed in the step of forming the outer shape, to arithmetic mean roughness Ra (JIS B 0601) of about 2 μm or less.

Advantageous Effects of Invention

According to the thrust roller bearing cage of the present invention and the method for manufacturing the same, running torque can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** shows a part of a thrust roller bearing cage according to an embodiment of the present invention.

FIG. **2** is a sectional view of the thrust roller bearing cage shown in FIG. **1**.

FIG. **3** is an enlarged sectional view showing a part of the thrust roller bearing cage shown in FIG. **2**.

FIG. **4** is a flowchart illustrating representative steps of a method for manufacturing the thrust roller bearing cage according to the embodiment of the present invention.

FIG. **5** is a sectional view of a cage material after a concave and convex portions forming step.

FIG. **6** is an enlarged sectional view showing a part of the cage material after a pilot hole forming step.

FIG. **7** is an enlarged sectional view showing a part of the cage material after an outer shape forming step.

FIG. **8** shows a part of the cage material after a pocket forming step.

FIG. **9** is an enlarged sectional view showing a part of the cage material after the pocket forming step.

FIG. **10** is an enlarged sectional view showing a part of the cage material during a radially outer area bending step.

FIG. **11** is an enlarged sectional view illustrating how the radially outer area bending step is performed.

FIG. **12** is an enlarged sectional view illustrating how the radially outer area bending step is performed.

FIG. **13** is an enlarged sectional view showing a part of the cage material after the radially outer area bending step.

FIG. **14** is an enlarged sectional view showing a part of the cage material after the radially outer area bending step.

FIG. **15** is an enlarged sectional view illustrating how the radially outer area bending step is performed.

FIG. **16** is an enlarged sectional view illustrating how a press-flattening step is performed.

FIG. **17** is an enlarged sectional view showing the tip of a radially outer area bent portion after the press-flattening step.

FIG. **18** is a sectional view showing a part of a thrust roller bearing cage according to another embodiment of the present invention.

FIG. **19** shows a part of a thrust roller bearing cage according to still another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will be described below with reference to the drawings. In the figures described below, the same or corresponding portions are denoted with the same reference characters, and description thereof will not be repeated.

FIG. **1** shows a part of a thrust roller bearing cage **11** according to an embodiment of the present invention. FIG. **1** shows the cage **11** as viewed in the direction of the rotation axis of the cage **11**. FIG. **2** is a sectional view of the thrust roller bearing cage **11** shown in FIG. **1**. FIG. **2** shows the cage **11** taken along line II-II in FIG. **1**. Specifically, a portion having a pocket, which will be described later, is shown in section on the right side of FIG. **2**, and a portion having a pillar, which will be described later, is shown in section on the left side of FIG. **2**. FIG. **3** is an enlarged sectional view showing a part of the thrust roller bearing cage **11** shown in FIG. **2**. The enlarged sectional view in FIG. **3** shows the area indicated by III in FIG. **2**. In FIGS. **2** and **3**, the rotation axis **12** of the cage **11** is shown by an alternate long and short dash line. For ease of understanding, FIG. **3** shows a needle roller **13** accommodated in a pocket **21** that will be described later, and a part of a pair of bearing rings **14**, **15** disposed on both sides of the cage **11** in the direction of the rotation axis of the cage **11**. The direction perpendicular to the plane of paper of FIG. **1** and the vertical direction in FIGS. **2** and **3** are the direction of the rotation axis of the cage **11**. The direction shown by arrow A_1 or its opposite direction in FIG. **1** is the circumferential direction. For ease of understanding, the upper side in FIGS. **2** and **3** is defined as the upper side in the axial direction. That is, the direction shown by arrow A_2 in FIGS. **2** and **3** is the upward direction. The lateral direction in FIGS. **2** and **3** is the radial direction. The direction shown by arrow A_3 in FIG. **3** is the radially outward direction.

First, the configuration of the thrust roller bearing cage **11** according to the embodiment of the present invention will be described with reference to FIGS. **1** to **3**. The thrust roller bearing cage **11** according to the embodiment of the invention is in the shape of a disc and has a through bore **22** extending straight through its central area in the thickness direction of the cage **11**. A rotary shaft, not shown, is inserted through the through bore **22**.

The cage **11** includes a pair of annular portions **23**, **24** with different diameters, and a plurality of pillars **25** formed at intervals in the circumferential direction so as to form the pockets **21** that accommodate the needle rollers **13** therein and connecting the pair of annular portions **23**, **24**. In this example, the cage **11** has 28 pockets **21** and **28** pillars **25**, although not all of the pockets **21** and the pillars **25** are shown in the figures.

The pockets **21** are substantially rectangular as viewed in the axial direction. The pockets **21** are arranged radially about the rotation axis **12** of the cage **11**. The pockets **21** have upper roller stoppers **26** and lower roller stoppers **27**, **28** on their side wall surfaces. The upper roller stoppers **26** prevent the needle rollers **13** accommodated in the pockets **21** from falling out upward in the axial direction, while the lower roller stoppers **27**, **28** prevent the needle rollers **13** accommodated in the pockets **21** from falling out downward in the axial direction. The upper roller stoppers **26** are formed in the middle parts in the radial direction of the pockets **21**. The lower roller stoppers **27** are formed in the radially inner parts of the pockets **21**, and the lower roller stoppers **28** are formed in the radially outer parts of the pockets **21**. The upper roller stoppers **26** and the lower roller stoppers **27**, **28** are formed on the side wall surfaces located on both sides in the circumferential direction of each pocket **21** so as to project into the pockets **21**.

The needle rollers **13** are pressed into the pockets **21** to fit in the pockets **21**. End faces of each needle roller **13**, specifically, an outer end face **16** in the bearing and an inner end face **17** in the bearing, are flat.

The cage **11** has concave and convex portions that are formed by bending a plate in the thickness direction thereof a few times. Specifically, the cage **11** includes four disc portions **31**, **32**, **33**, **34** extending in the radial direction and four cylindrical portions **36**, **37**, **38**, **39** extending in the axial direction. The four disc portions **31** to **34** are arranged in this order from the inside in the radial direction so that the first disc portion **31** has the smallest inside diameter, followed by the second disc portion **32**, the third disc portion **33**, and the fourth disc portion **34** in ascending order. The four cylindrical portions **36** to **39** are arranged in order of the first cylindrical portion **36**, the second cylindrical portion **37**, the third cylindrical portion **38**, and the fourth cylindrical portion **39** from the inside in the radial direction. The first cylindrical portion **36** and the second cylindrical portion **37** extend straight in the axial direction. The third cylindrical portion **38** is slightly tilted so that its radially inner part is located below its radially outer part in the axial direction. The fourth cylindrical portion **39**, which is the outermost cylindrical portion in the radial direction, is slightly tilted so that its radially inner part is located above its radially outer part in the axial direction. The upper roller stoppers **26** are formed in the third disc portion **33**. The lower roller stoppers **27** are formed in the second disc portion **32**, and the lower roller stoppers **28** are formed in the fourth disc portion **34**. The inner annular portion **23** in the radial direction includes the first disc portion **31**, a part of the second disc portion **32**, the first cylindrical portion **36**, and the second cylindrical portion **37**. The outer annular portion **24** in the radial direction includes a part of the fourth disc portion **34**, a radially outer area bent portion **41**, and projecting portions **44**. The radially outer area bent portion **41** and the projecting portions **44** will be described later. Each pillar **25** includes a part of the second disc portion **32**, the third disc portion **33**, a part of the fourth disc portion **34**, the third cylindrical portion **38**, and the fourth cylindrical portion **39**.

The cage **11** includes the radially outer area bent portion **41** that is formed by bending a radially outer area of the cage **11** inward in the radial direction. The radially outer area bent portion **41** is a standing wall standing in the axial direction and is formed to extend continuously in an annular shape. Specifically, the radially outer area bent portion **41** is formed by bending the radially outer area of the cage **11** inward in the radial direction along an annular groove formed at a position radially outside the pockets **21**. As shown in FIG. **3**, a trace **29** of the annular groove along which the radially outer area of the cage **11** is bent is left in the cage **11**. The trace **29** is a portion with a reduced thickness, a compression mark, etc.

The radially outer area bent portion **41** of the present embodiment is formed by bending the area located radially outside the pockets **21** obliquely inward in the radial direction. Specifically, the radially outer area bent portion **41** is formed by bending the radially outer edge of the fourth disc portion **34**, which is the outermost disc portion in the radial direction, upward in the axial direction to a predetermined angle.

The angle of the radially outer area bent portion **41**, namely the angle between a radially inner surface **42** of the radially outer area bent portion **41** and an upper surface **43** of the fourth disc portion **34**, is shown by an angle B_1 in FIGS. **2** and **3**. This angle may be 0°, but is preferably an acute angle.

The radially outer area bent portion **41** has the projecting portions **44** formed in its tip end at positions aligned with the pockets **21**. That is, the projecting portions **44** are formed at positions aligned with the pockets **21** and face inward in the radial direction. The positions aligned with the pockets **21** are such positions that the outer peripheral edges of the projecting portions **44** overlap the outer peripheral edges of the pockets **21**. That is, the radially inner edge of the radially outer area bent portion **41** overlaps the radially outer edges of the pockets **21**.

The projecting portions **44** project inward in the radial direction beyond the radially outer edges of the pockets **21** so as to contact the end faces **16** of the rollers **13** accommodated in the pockets **21**. Namely, the projecting portions **44** abut on the end faces of the rollers accommodated in the pockets **21** to restrict movement of the rollers toward the outside in the radial direction. Specifically, the projecting portions **44** are shaped to extend continuously from the inner peripheral edge of the radially outer area bent portion **41** toward the inside in the radial direction. That is, the radially outer area bent portion **41** and the projecting portions **44** are formed as a single-piece member.

The projecting portions **44** are formed at circumferential positions so that the tips of the projecting portions **44** are located in the middle parts in the circumferential direction of the pockets **21**. Specifically, the projecting portions **44** are formed so that their corners **45** on the surface **42** side, namely the innermost parts in the radial direction of the projecting portions **44** (the innermost corners **45** in the radial direction of the projecting portions **44**) contact the centers of the end faces **16** of the needle rollers **13** accommodated in the pockets **21**. In this example, the corners **45** are the corners of the projecting portions **44** which are located closer to the fourth disc portion **34**.

The cage **11** has three pilot holes **51**, **52**. The three pilot holes **51**, **52** serve as engagement portions for alignment. One of the pilot holes is not shown in FIG. **1**. The three pilot holes **51**, **52** are formed at intervals in the circumferential direction and extend straight through the cage **11** in the thickness direction of the cage **11**. The three pilot holes **51**, **52** open in a circular shape. The three pilot holes **51**, **52** are formed substantially equally spaced apart from each other. In this example, the three pilot holes **51**, **52** are formed at intervals of 120 degrees about the rotation axis **12** of the cage **11**. Specifically, the pilot holes **51**, **52** are formed in the middle part in the radial direction of the innermost first disc portion **31** in the radial direction. For example, the diameter of the pilot holes **51**, **52** is φ2.5 mm or φ3 mm.

For example, the thrust roller bearing **20** having such a cage **11** includes the plurality of needle rollers **13**, the upper bearing ring **14**, and the lower bearing ring **15**. When the thrust roller bearing **20** is in operation, the needle rollers **13** accommodated in the pockets **21** roll on a raceway surface **18** of the upper bearing ring **14** in the axial direction and a raceway surface **19** of the lower bearing ring **15** in the axial direction. The cage **11** rotates around its rotation axis **12**. Each of the needle rollers **13** accommodated in the pockets **21** revolves while rotating around its axis. The needle rollers

13 are subjected to a radially outward centrifugal force. The centers of the end faces 16 of the needle rollers 13 make sliding contact with the projecting portions 44 of the cage 11, specifically the innermost corners 45 in the radial direction of the projecting portions 44 of the cage 11. That is, the corners 45 of the projecting portions 44 are the areas that contact the end faces 16 of the needle rollers 13.

The corners 45 have been press-flattened. The corners 45 subjected to the press-flattening process have no sharply pointed parts and smoothly connect to the surfaces forming the corners 45. This reduces aggression of the corners 45 against members that are contacted by the corners 45.

Next, a method for manufacturing the thrust roller bearing cage 11 according to the embodiment of the present invention will be described. The thrust roller bearing cage 11 is manufactured by using a transfer press. The transfer press is a relatively inexpensive press machine with a less complicated configuration. FIG. 4 is a flowchart illustrating representative steps of the method for manufacturing the thrust roller bearing cage 11 according to the embodiment of the present invention.

Referring to FIG. 4, a cage material, which will later become the cage 11, is first prepared (cage material preparing step: step S1). For example, the cage material is a thin flat steel sheet. At this stage, the cage material may be either a plate cut into a substantially rectangular shape or a circular plate, as the final outer shape of the cage is formed in an outer shape forming step (step S4) that will be performed later.

Next, concave and convex portions are formed in the cage material in the thickness direction of the cage material (concave and convex portions forming step: step S2). This ensures that the cage 11 has a large length dimension in the direction of its rotation axis even if the cage 11 is in the shape of a thin plate, whereby the cage 11 can appropriately retain the rollers.

Specifically, in this step, the cage material is subjected to a drawing process. In this case, the concave and convex portions can be formed more efficiently. FIG. 5 is a sectional view of the cage material after the concave and convex portions forming step. The section shown in FIG. 5 corresponds to the section shown in FIG. 2. Specifically, referring to FIG. 5, a flat plate-like cage material 56 is subjected to a drawing process to form first to fourth disc portions 61 to 64 and first to fourth cylindrical portions 66 to 69. A circular through bore 57 is formed in the central part of the cage material 56 so as to extend therethrough in the thickness direction. That is, in this case, the cage material 56 has what is called a mountain-and-valley shape made by bending the cage material 56 a plurality of times in the axial direction.

Thereafter, pilot holes serving as engagement portions are formed (pilot hole forming step: step S3). FIG. 6 is an enlarged sectional view showing a part of the cage material 56 after the pilot hole forming step. The section shown in FIG. 6 corresponds to the area VI in FIG. 2. A pilot hole 71 serving as an engagement portion is formed in the middle part in the radial direction of the first disc portion 61 so as to extend straight through the first disc portion 61 in the thickness direction. Three of the pilot holes 71 are formed in total so as to be substantially equally spaced apart from each other at intervals of 120 degrees in the circumferential direction.

Subsequently, the outer shape of the cage material 56 is formed (outer shape forming step: step S4). FIG. 7 is an enlarged sectional view showing a part of the cage material 56 after the outer shape forming step. The section shown in FIG. 7 corresponds to the area VI shown in FIG. 2, and is a section taken along line VII-VII in FIG. 8. Specifically, in this example, the cage material 56 is punched straight in the thickness direction so that the cage 11 can be formed into the final outer shape by a radially outer area bending step (step S7) etc. that will be performed later. In this case, the outer shape of the cage material 56 can be formed relatively easily and accurately. A radially outer edge 72 of the cage 11, specifically, a radially outer edge 72 of the fourth disc portion 64, is thus formed.

When forming the outer shape, the cage material 56 is punched so as to form portions that will later become projecting portions 70. That is, in this case, the outer shape forming step is also a projecting portions forming step, i.e., the step of forming the projecting portions. FIG. 8 shows a part of the cage material 56 after a pocket forming step, which is the step following the outer shape forming step. FIG. 8 corresponds to FIG. 1. When punching the cage material 56 so as to form the projecting portions 70, the cage material 56 is aligned in the circumferential direction by using the plurality of pilot holes 71. Specifically, a plurality of guide pins (not shown), which serve as what is called pencil-like alignment jigs having a pointed end and having a tapered shape with its diameter gradually increasing from the pointed end, are prepared and are gradually inserted into the plurality of pilot holes 71 from one side in the thickness direction. The cage material 56 is thus aligned by using the plurality of guide pins and is punched into the overall outer shape with a punching machine (not shown) in view of the positions, the shape, etc. of the projecting portions 70. Accordingly, even if the cage material 56 is slightly out of alignment with the punching machine with respect to the proper positions where the projecting portions 70 are supposed to be formed, the cage material 56 can be aligned with the punching machine with respect to the proper positions where the projecting portions 70 are supposed to be formed, as the pencil-like guide pins having a pointed end are gradually inserted into the pilot holes 71. The punching process can thus be performed. In this example, since the cage material 56 has the three pilot holes 71, rotation etc. of the cage material 56 is prevented during alignment. The cage material 56 can thus be aligned more accurately.

Subsequently, pockets are formed (pocket forming step: step S5). FIG. 9 is an enlarged sectional view showing a part of the cage material after the pocket forming step. The section shown in FIG. 9 corresponds to the area III shown in FIG. 2 and is a section taken along line IX-IX in FIG. 8. In this example, each pocket 73 is punched out along a part of the second disc portion 62, the third disc portion 63, and a part of the fourth disc portion 64 and also along the third cylindrical portion 68 and the fourth cylindrical portion 69 so as to extend straight through the cage material 56 in the thickness direction. Although not shown in FIG. 9, the upper roller stoppers and the lower roller stoppers, which are shaped so as to project into the pockets 73 in the circumferential direction, are formed simultaneously with the pockets 73. That is, the pockets 73 are punched out in view of the shape of the upper roller stoppers and the lower roller stoppers so as to conform to the outer shape of needle rollers 13 that are to be accommodated in the pockets 73. The plurality of pockets 73 may be punched out either all at once or one by one.

When forming the pockets 73 in the cage material 56, the pilot holes 71 are also used to align the cage material 56 to be punched with a punching machine (not shown) for punching out the pockets. That is, the pockets 73 are formed with respect to the positions of the pilot holes 71. As in the case of the outer shape forming step, alignment in the circumferential direction is performed by using the plurality of pilot holes **71**. Specifically, a plurality of guide pins serving as sharp pencil-like alignment jigs are prepared and the tip ends of the guide pins are gradually inserted into the plurality of pilot holes **71** from one side in the thickness direction as described above. The cage material **56** is thus aligned by using the plurality of guide pins, and the pockets **73** are punched out with the punching machine in view of the positions, shape, etc. of the pockets **73**. The pockets **73** are thus formed in phase with the projecting portions **70** in the circumferential direction, so that an appropriate positional relationship can be established between the pockets **73** and the projecting portions **70**. Accordingly, the projecting portions **70** can be accurately and efficiently formed in terms of the positional relationship of the projecting portions **70** with the pockets **73** to be formed. Since the projecting portions **44** (see FIG. **3**) are accurately formed at the appropriate positions, end faces **16** of the needle rollers **13** can appropriately contact the projecting portions **44** when the bearing is in operation. The plurality of pockets **73** may be punched out either all at once or one by one.

In the present embodiment, the pilot holes **71** are formed in an area located radially inside the pockets **73**. In this case, the pilot holes **71** can be formed by making effective use of the available area of the cage **11**.

In the present embodiment, the pilot holes **71** are formed so as not to overlap the pockets **73** in the circumferential direction. This can avoid local strength reduction in the circumferential direction of the cage **11**. The positional relationship of the pockets **73** with the pilot holes **71** can be determined as desired. Specifically, in this example, the plurality of pockets **73** are formed so that each of the pilot holes **71** is located at a position corresponding to the middle in the circumferential direction between adjoining ones of the pockets **73**.

Subsequently, as shown in FIGS. **8** and **9**, an annular groove **79** is formed at a position radially outside the pockets **73** in the cage material (groove forming step: step S**6**). In this step (step S**6**), the annular groove **79** is formed at such a position that the cage material is to be bent along the annular groove **79** when forming a radially outer area bent portion **41** in the radially outer area bending step (step S7) which will be described below. A method for forming the groove **79** is not particularly limited. The groove **79** may be formed by pressing, cutting, etc., and it is preferable to form the groove **79** by pressing the cage material with a ring-shaped wedge. The shape of the groove **79** is not particularly limited. The groove **79** may have a pointed bottom or may have a curved bottom. The steps S4 to S**6** may be performed in any order.

Subsequently, an area of the cage material **56** which is located radially outside the pockets **73** is bent inward in the radial direction along the groove **79** to form a radially outer area bent portion (radially outer area bending step) (step S7). In this step, since the radially outer area of the cage material **56** is bent along the groove **79**, the bending position can be easily controlled, whereby positional accuracy can be improved and the radially outer area of the cage material **56** can be easily bent inward in the radial direction. In this step, it is preferable to form the radially outer area bent portion by bending the radially outer area of the cage material **56** obliquely inward in the radial direction to an acute tilt angle.

FIG. **10** is an enlarged sectional view showing a part of the cage material during the radially outer area bending step. FIGS. **11** and **12** are enlarged sectional views illustrating how the radially outer area bending step is performed. FIGS. **13** and **14** are enlarged sectional views showing a part of the cage material **56** after the radially outer area bending step. The sections shown in FIGS. **10** and **13** correspond to the area VI in FIG. **2**. The section shown in FIG. **14** corresponds to the area III in FIG. **2**. The sections shown in FIGS. **11** and **12** show the positional relationship of an area of the cage material **56** which is located radially outside the position corresponding to the area VI in FIG. **2** with holding members **101**, **102** and a pressing member **103**. In this example, as shown in FIG. **10**, the annular radially outer edge **72** of the cage material **56** is first bent along the entire circumference along the groove **79** so as to extend straight in the thickness direction. That is, the angle B_2 between a radially inner surface **75** of a radially outer area bent portion **74** and an upper surface **76** of the fourth disc portion **64** is approximately a right angle. For example, the radially outer edge **72** is bent to a right angle by the following method, although the present invention is not particularly limited to this method. As shown in FIG. **11**, the entire cage material **56** except for a radially outer area of the fourth disc portion **64** is sandwiched between the holding members **101**, **102** in the vertical direction and is held therebetween, and the pressing member **103** is placed under the radially outer area of the fourth disc portion **64**. As shown in FIG. **12**, the pressing member **103** is then moved upward. The radially outer area bent portion **74** can thus be formed at a right angle with respect to the fourth disc portion **64**.

Subsequently, as shown in FIGS. **13** and **14**, the radially outer area bent portion **74** is tilted further inward in the radial direction to form the radially outer area bent portion **74**. As shown in FIGS. **13** and **14**, the trace **29** of the annular groove along which the radially outer area of the cage material **56** is bent is left in this step.

The bending angle (tilt angle), that is, the angle between the radially inner surface **75** of the radially outer area bent portion **74** and the upper surface **76** of the fourth disc portion **64** is shown by an angle B_3 in FIGS. **13** and **14**. The angle B_3 corresponds to the angle B_1 described above. In other words, the angle B_1 is equal to the angle B_3. The angles B_1, B_3 are preferably an acute angle.

In this example, in terms of the positional relationship in the circumferential direction, the projecting portions **70** are formed at the positions corresponding to the middle parts in the circumferential direction of the pockets **73**. The projecting portions **70** are thus formed at appropriate positions. Since the radially outer area bent portion **74** is bent at a desired position due to the annular groove **79**, the projecting portions **70** are formed at appropriate positions. Specifically, the projecting portions **70** abut on the centers of the end faces **16** of the needle rollers **13** at their corners **77** located closer to the fourth disc portion **64**. Finally, the areas of the projecting portions **70** which are to contact the end faces **16** of the needle rollers **13** are subjected to a press-flattening process. The thrust roller bearing cage **11** configured as shown in FIGS. **1** to **3** is thus manufactured.

The step of tilting the radially outer edge **72** of the cage material **56** inward in the radial direction after the annular radially outer edge **72** is bent so as to extend straight in the thickness direction and the press-flattening process may be performed successively. FIG. **15** is an enlarged sectional view illustrating how the radially outer area bending step is performed. FIG. **16** is an enlarged sectional view illustrating how the press-flattening step is performed. FIG. **17** is an enlarged sectional view showing the tip of the radially outer area bent portion after the press-flattening step.

Specifically, as shown in FIG. **15**, after the cage material **56** is bent so that the radially outer area bent portion **74** extends at a right angle with respect to the fourth disc portion **64**, an area of the cage material **56** which is located radially inside the radially outer area bent portion **74** is sandwiched between dies **104**, **105** in the vertical direction and is held therebetween. At this time, the radially outer edge of the upper die **104** is located radially inside the radially outer edge of the lower die **105**. A die **106** that presses the radially outer area bent portion **74** downward from above is also placed so as to contact a radially outer surface **78** of the radially outer area bent portion **74**. The die **106** includes a radially inner end face **106***a* that faces the upper die **104** and extends in the vertical direction, a horizontal face **106***b* that is continuous with the radially inner end face **106***a* and extends outward in the radial direction, and a radially inner face **106***c* that faces the radially outer surface **78** of the radially outer area bent portion **74** and extends in the vertical direction. A part **106***d* of the die **106** where the horizontal face **106***b* and the radially inner face **106***c* meet has a round (R) shape. When the die **106** is moved downward so that the radially inner end face **106***a* moves along a radially outer end face **104***a* of the die **104**, the radially outer area bent portion **74** can be tilted inward in the radial direction as guided by the round part **106***d*. As shown in FIG. **16**, the annular groove **79** thus leaves the trace **29** that is a compression mark formed by pressing.

Subsequently, as shown in FIG. **16**, the die **104** is moved further downward so that the radially inner corner of the radially outer area bent portion **74** is smoothed by the radially outer end face **104***a* of the die **104** and the radially outer corner of the radially outer area bent portion **74** is smoothed by the horizontal face **106***b* of the die **106**. As shown in FIG. **17**, the projecting portions **70** subjected to the press-flattening process in the areas of the projecting portions **70** which are to contact the end faces of the rollers can be formed in this manner.

As described above, according to the thrust roller bearing cage **11** of the present embodiment and the method for manufacturing the same, the annular groove **79** is formed at a position radially outside the pockets **73** in the groove forming step (step S**6**), and the radially outer area of the cage material is bent inward in the radial direction along the groove **79** in the radially outer area bending step (step S**7**) to form the radially outer area bent portion **74**. Since the radially outer area of the cage material is bent along the annular groove **79**, the bending position can be controlled. Moreover, the annular groove **79** facilitates bending of the radially outer area of the cage material even when the rim portion that is bent has a small length in the radial direction. Accordingly, regarding the projecting portions that are formed in the tip end of the radially outer area bent portion **42**, those parts of the projecting portions which are to contact the centers of the end faces of the needle rollers can be accurately aligned, whereby running torque can be reduced. A trace of the annular groove **79** is left in such a cage **11**.

In the above embodiment, the corners of the projecting portions which are located closer to the fourth disc portion contact the centers of the end faces of the needle rollers accommodated in the pockets. However, the present invention may have the following configuration. FIG. **18** is a sectional view showing a part of a cage having this configuration. FIG. **18** corresponds to the section shown in FIG. **3**.

Referring to FIG. **18**, a thrust roller bearing cage **81** according to another embodiment of the present invention has a radially outer area bent portion **82** having projecting portions **83** formed at positions corresponding to the positions of pockets **85**. The projecting portions **83** contact the centers of end faces **16** of needle rollers **13** accommodated in the pockets **85** at corners **84** located on the opposite side of the projecting portions **83** from a fourth disc portion **86**. The corners **84** have been press-flattened. This configuration can be achieved by machining the corners **84** with a jig angled so as to conform to the corner **84** in the radially outer area bending step. A trace **89** of an annular groove along which the radially outer area bent portion **82** is bent is left in the cage **81** shown in FIG. **18**.

A pilot hole may be formed at a position where a pocket is supposed to be formed. In other words, one of the plurality of pockets may be used as a pilot hole. FIG. **19** shows a part of a cage having this configuration. Referring to FIG. **19**, a thrust roller bearing cage **91** according to still another embodiment of the present invention includes a plurality of pockets **92** and pillars **93** each located between adjoining two of the pockets **92**. A pilot hole **95** is formed at a position where a pocket **92** is supposed to be formed in a pillar **94** located between the pockets **92**. In this configuration, one of the plurality of pockets **92** that are formed equally spaced apart from each other in the circumferential direction is replaced with this pilot hole **95**.

In the above embodiment, the pilot holes extend straight through the cage in the thickness direction. However, the present invention is not limited to this. For example, the pilot holes extending through the cage may have a tapered wall surface. The pilot holes are not limited to the circular holes and may be quadrilateral holes, triangular holes, etc. The pilot holes are formed as engagement portions. However, the present invention is not limited to this. The engagement portions may have other configurations. For example, the engagement portions may be formed by cutouts.

In the above embodiment, a drawing process is performed in the concave and convex portions forming step. However, the present invention is not limited to this. A process other than the drawing process, such as a bending process, may be used to form concave and convex portions.

In the above embodiment, the cage has the concave and convex portions that are formed in the thickness direction. However, the present invention is not limited to this. The cage may not have the concave and convex portions that are formed in the thickness direction, and a cage in the form of what is called a laminate of two plates may be used.

In the above embodiment, the thrust roller bearing having such a cage as described above may not have bearing rings. Rollers other than the needle rollers, such as long rollers etc., may be used.

The embodiments disclosed herein are by way of example in all respects and should not be interpreted as restrictive. The scope of the present invention is defined by the claims rather than by the above embodiments, and the invention is intended to cover all changes and modifications within the spirit and scope of the invention as defined by the claims.

INDUSTRIAL APPLICABILITY

The thrust roller bearing cage according to the present invention and the method for manufacturing the same are effectively utilized to meet demands for thrust roller bearing cages with excellent performance and more efficient methods for manufacturing such a thrust roller bearing cage.

REFERENCE SIGNS LIST

11, **81**, **91** Cage
12 Rotation Axis

13 Roller
14, **15** Bearing Ring
16, **17** End Face
18, **19** Raceway Surface
20 Thrust Roller Bearing
21, **73**, **85**, **92** Pocket
22, **57** Through Bore
23, **24** Annular Portion
25, **93**, **94** Pillar
26, **27**, **28** Roller Stopper
29, **89** Trace
31, **32**, **33**, **34**, **61**, **62**, **63**, **64**, **86** Disc Portion
36, **37**, **38**, **39**, **66**, **67**, **68**, **69** Cylindrical Portion
41, **74**, **82** Radially Outer Area Bent Portion
42, **43**, **75**, **76**, **78** Surface
44, **70**, **83** Projecting Portion
45, **77**, **84** Corner
51, **52**, **71**, **95** Pilot Hole
56 Cage Material
72 Edge
79 Groove
101, **102** Holding Member
103 Pressing Member
104, **105**, **106** Die
104*a* Radially Outer End Face
106*a* Radially Inner End Face
106*b* Horizontal Face
106*c* Radially Inner Face
106*d* Part

The invention claimed is:

1. A thrust roller bearing cage included in a thrust roller bearing and including a plurality of pockets accommodating rollers, comprising:

a radially outer area bent portion formed by bending the cage inward in a radial direction along an annular groove formed at a position radially outside the pockets; and

projecting portions that are formed in a tip end of the radially outer area bent portion at positions aligned with the pockets and project inward in the radial direction beyond radially outer edges of the pockets so as to contact end faces of the rollers accommodated in the pockets, wherein

a trace of the groove is left at a position along which the cage is bent.

2. The thrust roller bearing cage according to claim **1**, wherein

areas of the projecting portions which are to contact the end faces of the rollers are subjected to a press-flattening process.

3. A method for manufacturing a thrust roller bearing cage included in a thrust roller bearing and including a plurality of pockets accommodating rollers, comprising the steps of:

preparing a cage material that will later become the cage;

forming an outer shape of the cage material so that the outer shape has portions that will later become projecting portions projecting inward in a radial direction beyond radially outer edges of the pockets so as to contact end faces of the rollers accommodated in the pockets;

forming the pockets in the cage material;

forming an annular groove at a position radially outside the pockets in the cage material; and

forming a radially outer area bent portion by bending an area of the cage material which is located radially outside the pockets inward in the radial direction along the annular groove.

4. The method for manufacturing the thrust roller bearing cage according to claim **3**, further comprising the step of:

press-flattening areas of the projecting portions which are to contact the end faces of the rollers.

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